Laboratory Environment Safety and Health Committee
Cryogenic Safety Subcommittee

MINUTES OF MEETING 04-10

November 3, 2004

Final

Committee Members Present	Committee Members Absent
R. Alforque	P. Mortazavi
W. Glenn	M. Rehak
S. Kane	
P. Kroon	
E. Lessard (Chairperson)	
A. Sidi Yekhlef	
R. Travis* (Secretary)	
K. C. Wu	

(* non-voting)

Visitors
A. Etkin
R. Petricek
S. Plate
J. Tuozzolo

Agenda:

1. **Review of the AGS Snake Magnet**

Minutes of Meeting: Appended on pages 2 through 4.

Signature on File	11/24/04	Signature on File	11/24/04
E. Lessard	Date	J. Tarpinian	Date
LESHC Chairperson		ESH&Q ALD	

DM2120.

Chairperson E. Lessard called the tenth meeting in 2004 of the Laboratory Environmental Safety and Health Committee (LESHC) to order on November 3, 2004 at 1:33 p.m.

1. **Review of the AGS Snake Magnet:** E. Lessard invited S. Plate (Superconducting Magnet Division) and A. Sidi-Yekhlef (Collider-Accelerator Department), to present the AGS Snake Magnet to the Committee [1].
   1.1. Mr. Plate, Mr. Sidi-Yekhlef and other attendees made the following points during the course of the presentation and in response to specific Committee questions:

      1.1.1. This snake magnet is the first cryogenic magnet at the AGS. Its design is similar to the cryo-cooled snake magnets installed at RHIC.
      1.1.2. The cryohead is mounted directly on the magnet vessel. The compressors are located outside the tunnel. In addition to the integral cryocooler overpressure protection, the system piping has several relief valves (set at 55 psia) and one 60 psia rupture disk.
      1.1.3. The magnet is cooled to ~ 4 ^{o}K at 17 psia using commercially available cryo-coolers. C-AD agreed to provide the manufacturer's catalog sheet to the Committee.
      1.1.4. The cryocoolers were manufactured in Japan. It was not known if they are approved by a nationally recognized testing laboratory (NRTL), such as Underwriter's Laboratory. C-AD agreed to provide this documentation, if available. In lieu of NRTL approval, the Committee noted that a Laboratory Electrical Safety Committee member could perform an electrical safety review of the cryocoolers.
      1.1.5. The ASME Code calculations were presented to the Committee. Much discussion ensued. The following issues were raised:
         1.1.5.1. The cold bore tube weld attachment to the shell should be analyzed for bending stress.
         1.1.5.2. The level probe housing (Sheet 4 of the presentation) has an internal pressure load and constrained at the edges. The calculation must be performed for this geometry.
         1.1.5.3. Sheet 9 of the presentation shows highly localized stresses above Code allowables. The premise is that localized self limiting yielding would occur. Since this is an internal pressure load, there was some question if yielding would be self limiting.
         1.1.5.4. The fill and vent tubes are not laterally constrained. If the bellows squirm, it could overstress and buckle the attached tubing.
      1.1.6. Committee Member Steve Kane volunteered to check the stress calculations and offer additional comments for incorporation.
      1.1.7. During the bending of the heat shield aluminum tubing, one tube snapped. An intact tube was cut at the bend. Wall thickness was reduced from .035 to .015 inches. C-AD agreed to verify the minimum bend radius for this tubing.

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[1] Mr. Plate's presentation and these Minutes are posted on the LESHC website: http://www.rhichome.bnl.gov/AGS/Accel/SND/laboratory_environemnt,_safety_and_health_committee.htm.)

1.1.8. There was also a concern about work hardening of the tubes at the bend. C-AD agreed to cold shock the tubes and perform a 125% pressure test prior to installation in the magnet.

1.1.9. The magnet is precooled using liquid nitrogen, which is purged prior to the introduction of liquid helium. The procedure for introduction of cryogens into the tunnel and the magnet cool down will be developed and put into the Cryogenic Controls chapter of the C-AD OPM. Committee approval of this procedure is required prior to cool down in the AGS Tunnel. Steve Kane agreed to review the procedure on the behalf of the Committee.

1.1.10. One potential concern (which will be clarified by the procedure) is the use of a common LHe-LN2 vent line. The fourteen-inch diameter penetration proved limiting and necessitated the common vent line.

1.1.11. There is no liquid nitrogen in the AGS tunnel when the beam is on. However, the dose to the LN2 from residual radiation in the tunnel could be significant, depending on a number of factors including: LN2 residence time, time after AGS shutdown and LN2 line routing. This dose should be determined beforehand not to be an issue or tracked in a procedure to keep the production of explosive solid ozone to safe levels.

1.1.12. In the case of a large quench, approximately 110 liters of LHe and a smaller amount of gas will vent into the tunnel. Under these conditions the oxygen is reduced to 20.38%. C-AD agreed to transmit the ODH calculation to the Committee. Committee Member Woody Glenn agreed to review this calculation.

1.1.13. The magnet will be tested in Building 902 before emplacement in the AGS Tunnel. The Committee will have the opportunity to review the test configuration prior to the start of testing.

1.2. The following motion was crafted by the Committee:

1.2.1. Motion No. 1 - The operation of the AGS Snake Magnet is approved subject to the following conditions:

1.2.1.1. Review the Static Magnet Fields Subject Area and implement the appropriate requirements. Please contact the Static Magnetic Fields SME (Nicole Bernholc) for additional guidance.

1.2.1.2. Perform a NESHAPS evaluation of the tritiated LHe that would be released due to a large quench. **Complete – ref. 12/6/04 memo B. Hooda to M. VanEssendelft**

1.2.1.3. Provide the cryocooler manufacturer's catalog information. (See 1.1.3 above.)

1.2.1.4. Provide the nationally recognized testing laboratory electrical certification for the cryocooler. (See 1.1.4 above.)

1.2.1.5. Contact the C-AD Electrical Systems (Jon Sandberg) and arrange for an electrical safety review of the quench protection circuitry.

1.2.1.6. Provide the ASME Code calculations for Committee review and approval.

1.2.1.7. Determine the minimum allowable bend radius of the heat shield aluminum tubing (1.1.7).

1.2.1.8. Perform a pressure test of the heat shield aluminum tubing, as discussed in 1.1.7 and 1.1.8 above.
1.2.1.9. Provide the magnet operating procedures for Committee review and approval. (See 1.1.9 and 1.1.10 above.)
1.2.1.10. Confirm the setpoints of all relief valves and provide this information to the Committee.
1.2.1.11. Provide the oxygen deficiency calculations for Committee review and approval.
1.2.1.12. Transmit information on the relief valve venting arrangements inside the tunnel. Confirm that all RV discharges are directed away from personnel.
1.2.1.13. Determined beforehand the dose to the LN2 and show it is not an issue or track the dose to the LN2 from residual radiation in the AGS tunnel in a procedure to keep the production of explosive solid ozone to safe levels. (See 1.1.11 above.)

1.2.2. Recommendation for Approval of the Motion was made by W. Glenn.
1.2.3. Seconded by S. Kane
1.2.4. The motion was approved by vote of five in favor, none opposed. (The meeting ran late and several members had to leave prior to the vote.)

2. The Meeting was adjourned at 3:15 p.m.

Reference:
1. C-AD Drawing D18-M-4631, "AGS Cold Snake Magnet P&ID", Rev. B

Lessard, Edward T

Subject:	Updated: REMINDER MEETING TODAY! - LESHC 04-10, AGS Snake Magnet
Location:	Berkner Hall, Room D
Start:	Wed 11/3/2004 1:30 PM
End:	Wed 11/3/2004 3:00 PM
Recurrence:	(none)
Meeting Status:	Accepted
Required Attendees:	Travis, Richard J; Alforque, Rodulfo; Glenn, Joseph W; Kane, Steven F; Kroon, Peter J; Lessard, Edward T; Mortazavi, Payman; Rehak, Margareta L; Sidi-Yekhlef, Ahmed; Wu, Kuo-Chen; Plate, Stephen; Petricek, Robert J
Optional Attendees:	Bernholc, Nicole M; Beuhler, Robert; Gill, Ronald L; Ginsberg, Theodore; Gunther, William E; Kahnhauser, Henry F; Lee, Robert J; Williams, Patricia; Bebon, Michael J; Tarpinian, James; Kirk, Thomas B; Lowenstein, Derek I; Bergh, Paul J; Etkin, Asher; VanEssendelft, Melvin J; Ellerkamp, John J; Greves, Linda E

Rudy and K.C.,
I haven't heard from you ...... Please let me know if you can make it.
Thanks,
Rich

Rudy, Woody, Steve, Pete, Ed, Payman, Margareta, Ahmed and K.C.,
The C-A Department has requested a review of a the AGS Snake Magnet by the LESHC Cryo Subcommittee. This will be the first cryo magnet at AGS. This new Siberian snake spin rotator will use a superconducting helical dipole magnet. It will be much stronger than the present solenoid based snake and will not produce any orbit coupling. The construction will be based on the experience from the helical dipoles used for the RHIC Siberian snakes.

As background:
An informational meeting was hosted by Steve Plate for the Cryo Subcommittee on 2/3/04. I have attached the background information for your use.

Final Version Minutes: AGS Sna...

LESHC Cryo ıbcommittee - AGS

RE: LESHC Cryo Subcommittee - ...

Nicole, Bob B., Ron, Ted, Bill, Henry, Bob L., and Pat,
As a Cryo Subcommittee Meeting, this notice is for your info only. However, please feel free to attend if you have an interest in this particular review.

Thanks,
Rich Travis
LESHC Secretary

Environmental & Waste Management Services Division

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Upton, NY 11973-5000
Phone 631 344-8107
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BROOKHAVEN
NATIONAL LABORATORY

Managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

Date: ***December 6, 2004***

To: ***Melvin VanEssendelft***

From: ***Benny Hooda***

Subject: ***NESHAPs Review of Tritium Production in Helium at the AGS Snake Magnet***

As per your request, a NESHAPs compliance review of the white paper titled "An Estimation of Tritium Production in Helium in the AGS Snake Magnet" by E. Lessard and A. Sidi-Yekhlef, dated November 22, 2004 was completed.

The AGS facility is compliant with NESHAPs regulations even though the potential for fugitive losses of tritium exits near the Snake Magnet cryogenic cooling system within the AGS Ring. The potential for tritium production in the liquid helium, used to cool the AGS Snake Magnet, is possible due to secondary and tertiary hadrons scattering and absorption interactions. Only a small quantity (19.5 mCi) of tritium in all three Snake Magnet cooling systems would be produced even with the most conservative assumptions; such as using the highest value of helium cross section, independent spallation cross section above 100 MeV energy and similar cross section for all types of particles/ interactions. The tritium saturation concentration in the AGS Ring will be well below the derived air concentration and consequently the fugitive losses, if any, to the environment will be insignificant.

Based on the conservative criteria that all the tritium produced in the magnet quench was released to the environment, a NESHAPs compliance dose estimate was done using the EPA's CAP88-PC, version 3.0 dose modeling program. The potential effective dose equivalent was well below the 10 mrem/year annual limit as specified in the 40 CFR 61, subpart H, and below the 0.1mrem/ yr. limit, which would require a NESHAPs permit, and continuous monitoring of the emission source. The synopsis report from the dose-modeling program is attached that gives the effective dose equivalent to the maximally exposed individual in the southwest direction as 3.39E-8 mrem/year. An annual confirmatory air sample taken and analyzed for gamma emitting radionuclides in accordance with C-A OPM 9.5.12 also showed that there were no emissions of any other radionuclide from the AGS Ring.

If you have any questions regarding the NESHAPs review, please call Benny Hooda at extension 8107.

BH:car

Distribution: G. Goode R. Karol R. Lee E. Lessard A. Sidi-Yekhlef
R. Travis

File: EC72ER.04

* * *

C A P 8 8 - P C

Version 3.0

Clean Air Act Assessment Package - 1988

S Y N O P S I S   R E P O R T

Non-Radon Population Assessment
Dec 3, 2004 01:02 pmm

Facility: AGS Ring (Building 913)
Address: Brookhaven National Laboratory
P.O. Box 5000
City: Upton
State: NY   Zip: 11973

Source Category: Area
Source Type: Area
Emission Year: 2005

Comments: Tritium Production due to Hadrons interaction
with liquid helium cooling snake magnets at the AG

Effective Dose Equivalent
(mrem/year)

3.39E-08

At This Location: 1600 Meters Southwest

Dataset Name: AGS_2005
Dataset Date: 12/3/2004 1:02:00 PM
Wind File: Z:\CAP88PC2\CAP88PC2\WNDFILES\BNL00.WND
Population File: C:\Program Files\CAP88-PC30\Poplib\BNLB01.PO

MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 1600 Meters Southwest
Lifetime Fatal Cancer Risk: 1.06E-12

FREQUENCY DISTRIBUTION OF LIFETIME FATAL CANCER RISKS

Risk Range	# of People	# of People in This Risk Range or Higher	Deaths/Year in This Risk Range	Deaths/Year in This Risk Range or Higher
1.0E+00 TO 1.0E-01	0	0	0.00E+00	0.00E+00
1.0E-01 TO 1.0E-02	0	0	0.00E+00	0.00E+00
1.0E-02 TO 1.0E-03	0	0	0.00E+00	0.00E+00
1.0E-03 TO 1.0E-04	0	0	0.00E+00	0.00E+00
1.0E-04 TO 1.0E-05	0	0	0.00E+00	0.00E+00
1.0E-05 TO 1.0E-06	0	0	0.00E+00	0.00E+00
LESS THAN 1.0E-06	5047193	5047193	1.05E-09	1.05E-09

RADIONUCLIDE EMISSIONS DURING THE YEAR 2005

Nuclide	Class	Size	Source #1 Ci/y	TOTAL Ci/y
H-3	V	0.00	2.0E-02	2.0E-02

SITE INFORMATION

Temperature: 10 degrees C
Precipitation: 110 cm/y
Humidity: 8 g/cu m
Mixing Height: 1000 m

SOURCE INFORMATION

Source Number: 1

Source Height (m): 2.00
Area (sq m): 4.00

Plume Rise Pasquill Cat:	A	B	C	D	E	F	G
Zero:	0.00	0.00	0.00	0.00	0.00	0.00	0.00

AGRICULTURAL DATA

	Vegetable	Milk	Meat
Fraction Home Produced:	0.000	0.000	0.000
Fraction From Assessment Area:	0.000	0.000	0.000
Fraction Imported:	1.000	1.000	1.000

Beef Cattle Density: 5.83E-02
Milk Cattle Density: 8.56E-02
Land Fraction Cultivated
for Vegetable Crops: 1.88E-02

POPULATION DATA

Distance (m)

Direction	250	850	1600	2250	2750	6300	16800
N	0	0	0	0	1	4650	0
NNW	0	0	0	1	1	7845	0
NW	0	0	0	0	1	18410	1605
WNW	0	0	0	0	1	42735	59885
W	0	0	0	0	1	50715	137075
WSW	0	0	0	0	1	38830	147520
SW	0	0	97	0	1	22325	66440
SSW	0	0	198	0	1	21875	1120
S	0	0	0	0	1	15900	35
SSE	0	0	0	0	1	22925	0
SE	0	0	0	1	1	9270	16325
ESE	0	0	0	0	1	6375	7080
E	0	0	0	0	1	3095	765
ENE	0	0	0	0	1	2540	0
NE	0	0	0	0	1	3015	0
NNE	0	0	0	0	1	7740	0

Distance (m)

Direction	32000	48000	64000
N	94925	252075	262180
NNW	211745	108585	54880
NW	137435	124535	104675
WNW	135	217780	131090
W	243225	227190	373120
WSW	360480	427075	778140
SW	3495	0	0
SSW	0	0	0
S	0	0	0
SSE	0	0	0
SE	0	0	0
ESE	0	0	0
E	11765	9250	585
ENE	13175	15220	2300
NE	0	13750	33525
NNE	7125	45010	66315

An Estimation of Tritium Production in Helium in the AGS Snake Magnet

Edward T. Lessard and Ahmed Sidi-Yekhlef

November 22, 2004

The AGS beam for part of the FY2005 running period for the nuclear physics program will be high-energy polarized protons directed from the AGS to the AtR transfer line. Some protons will be displaced from the beam within the ASG Ring. Secondary and tertiary hadrons arising from primary beam losses will interact in the helium liquid that cools the AGS Snake Magnet, which is used to maintain the polarization of protons in the beam. The question was raised as to whether AGS beam losses in the vicinity of the Snake Magnet would generate a significant amount of tritium in the liquid helium coolant and if there would be significant tritium gas emission in the helium boil off that would be routinely vented from the AGS Ring. This note presents calculations to address those questions.

The basic assumption is that heat in the Snake Magnet cryogenic cooling system is from ionization in the coolant. This is an overestimate of the amount of ionization in the coolant but it is done this way in order to quantify the maximum possible release of tritium while simplifying the determination of the irradiating fluence. It is noted that operation of the Snake Magnet cooling system outside its anticipated parameter for heat load, 2 watts, is not intended for significant periods of time. There are three cryo-coolers each capable of removing about 1.5 watts for helium at 4.5 ^{o}K. It is not possible to run the Snake Magnet if the heat load exceeds the total capacity of the cryo-coolers.

Beginning with a well-established formula for activation:[1]

$$P = \sum_{jk} N \int_{E_{jk}}^{E_{kmax}} \sigma_{jk}(E)\ \varphi_k\, dE \qquad \text{Eq. 1}$$

where P is the constant production rate of tritium atoms in the helium, atoms s^{-1},
N is the number of He atoms in the cooling system,
σ_{jk} is the cross section for a particle of type k producing a tritium atom via reaction j, cm^2,
φ_k is the fluence rate of particles of type k, particles/cm^2 s,
E is the particle energy, with E_{jk} being the threshold energy for reaction j with particle k, and $E_{k\max}$ is the maximum energy of particle type k.

This first equation assumes that there is only one radionuclide of interest, tritium. Some other simplifying assumptions are:

- The production of tritium is dominated by hadronic-spallation reactions, without significant contributions from reactions involving leptons, photons or secondary processes. This assumption eliminates the summation over *j*.
- The cross section for tritium production is essentially the same for all hadrons. This is reasonable given spallation is a strong interaction and eliminates the summation over *k*, allowing one to use the total number of hadrons to calculate φ.
- The spallation cross section is essentially independent of hadron energy above 100 MeV.[1] This assumption eliminates the integration over *E*.

Using first-order linear kinetics, the number tritium atoms in the coolant at any time is given by:[2]

$$H = \frac{P(1 - e^{-(\lambda + K)t})}{\lambda + K} \quad \text{Eq. 2}$$

where H is the number of tritium atoms in the helium coolant at any time,
λ is the decay constant of tritium = 1.79×10^{-9} s^{-1},
K is the boil-off constant for tritium, 0.1 g s^{-1}/12300 g = 8.13×10^{-6} s^{-1}, and
t is the irradiation time.

This second equation allows for no decay post shutdown; that is, it gives the tritium atoms at the moment the beam is turned off. The second equation also assumes there are two tritium removal rates at work during irradiation: loss of tritium due to helium boil-off and due to radioactive decay.

Combining the first and second equations with the simplifying assumptions yields:

$$H = \frac{N\sigma\varphi(1 - e^{-(\lambda + K)t})}{\lambda + K} \quad \text{Eq. 3}$$

Determination of N is straightforward from Avogadro's number, the mass of liquid helium in the Snake Magnet and the molecular weight of liquid helium:

$$N = \frac{\rho}{M} N_A = (12300 \text{ g} / 4.00 \text{ g mol}^{-1})(6.02 \times 10^{23} \text{ atoms mol}^{-1}) = 1.85 \times 10^{27} \text{ atoms}$$

Deciding on a value for cross section for tritium production from spallation of helium by hadrons is less straightforward and represents most of the uncertainty in this estimate. No measured cross section for the production of tritium through hadronic spallation of helium has been located. However, tritium production cross sections have been compiled for reactions with other targets.[3] Plots of cross section versus atomic number show the cross section falling for light elements. Visual inspection places the cross section for helium-4 as low as 5 mb or as high as 30 mb. Additionally, one can calculate 30 mb for the cross section using Reference 4. Thus, 30 mb is chosen here as a reasonable yet conservative estimate for cross section for this specific reaction on helium.

The following assumptions are made in estimating fluence rate, φ. The heat load in the liquid helium is reported to be 2 watts under normal operation. This heat load is assumed to be due to secondary and tertiary hadron interactions in helium. The absorbed dose per unit hadron fluence is taken from Reference 5, page 24, as $3.2\text{x}10^{-14}$ Gy m^2 $hadron^{-1}$. The fluence rate into the helium coolant can be calculated from the heat load and absorbed dose per unit hadron fluence as follows:

$$\varphi = (2 \text{ watts}/12300 \text{ g})(10^7 \text{ erg/s/watt})(1 \text{ rad}/100 \text{ ergs g}^{-1})(1 \text{ Gy}/100 \text{ rad})/(3.2\text{x}10^{-14} \text{ Gy m}^2 \text{ hadron}^{-1})$$

$$\varphi = 5.08\text{x}10^{12} \text{ hadrons/m}^2 \text{ s}$$

The irradiation time is assumed to be eight weeks, which is $4.84\text{x}10^6$ s. Using Eq. 3, the number of tritium atoms in the helium coolant at the end of eight weeks is:

$$H = (1.85\text{x}10^{27} \text{ atoms})(30 \text{ mb})(10^{-27} \text{ cm}^2/\text{mb})(5.08\text{x}10^{12} \text{ hadrons/m}^2 \text{ s})(1 \text{ m}^2/10^4 \text{ cm}^2)$$
$$(1\text{-e}^{-(0.00000000179/\text{s} + 0.00000813/\text{s})(4{,}840{,}000 \text{ s})})/(1.79 \times 10^{-9} \text{ s}^{-1} + 8.13\text{x}10^{-6} \text{ s}^{-1})$$

$$H = 3.47\text{x}10^{15} \text{ tritium atoms}$$

The tritium activity, A, in the helium coolant is given by:

$$A = H\lambda$$

$$A = (3.47\text{x}10^{15} \text{ tritium atoms})(1.79\text{x}10^{-9} \text{ s}^{-1})$$

$$A = 1.68\text{x}10^8 \text{ pCi}$$

$$A = 6.22\text{x}10^6 \text{ Bq}$$

The tritium release rate, Q, from boil-off is given by:

$$Q = HK$$

$$Q = (3.47\text{x}10^{15} \text{ tritium atoms})(8.13\text{x}10^{-6} \text{ s}^{-1})$$

$$Q = 2.82\text{x}10^{10} \text{ atoms/s}$$

$$Q = 1360 \text{ pCi/s}$$

$$Q = 50.3 \text{ Bq/s}$$

The Derived Air Concentration (DAC) for the Annual Limit on Intake of a radionuclide is that concentration which will deliver the annual limit of dose equivalent to a worker who continuously occupies an area at one DAC for one working year (2000 hours). In the case of tritium, the DAC is 8×10^5 Bq/ml.[6] The tritium in the Snake Magnet is mixed with 12300 g of liquid helium, which is 9.8×10^4 cc of liquid, and the liquid to gas expansion ratio is 768 at 300 ^oK. The resulting airborne tritium concentration is at least seven orders of magnitude less than the DAC, and it would exist temporarily in the vicinity of the Snake Magnet after a loss of coolant event inside the AGS Ring. Therefore, no significant radiological hazard to a worker exists.

From the standpoint of environmental protection, one considers the total amount of tritium released from a magnet quench and assumes that all of it is vented to the outside. The other environmental consideration is routine emission of tritium with the helium boil off for eight weeks of operation. Using EPA's CAP88 Code with BNL site parameters, the maximum dose to an individual off site would be 1.8×10^{-8} mrem for the quench event and 6.8×10^{-7} mrem during the eight week program from routine tritium emissions.[7] Even if the cryo-coolers were run at full capacity of 4.5 watts, rather than at the expected routine level of 2 watts, off-site doses would be well below the 0.1 mrem per year trigger for monitoring requirements prescribed by EPA in 40 CFR 61.

References

1. H. W. Patterson and R. H. Thomas, Accelerator Health Physics, p. 519, Academic Press, New York (1973)
2. Skrable K., French C., Chabot G., Major A., A General Equation For The Kinetics Of Linear First Order Phenomena And Suggested Applications, Health Phys. 27(1):155-7, (1974).
3. A. Konobeyev and A. Korovin, Nuclear Instruments And Methods, V 82, p.103, (1993)
4. M. Barbier, Induced Radioactivity, North-Holland Publishing Company, Amsterdam and London (1969)
5. A. H. Sullivan, A Guide to Radiation and Radioactivity Levels Near High Energy Particle Accelerators, Nuclear Technology Publishing, Kent, England (1992)
6. U. S. Department of Energy, *Occupational Radiation Protection; Final Rule*, 10 CFR 835, Appendix A, (1993)
7. U. S. Environmental Protection Agency, CAP88-PC provides a framework for developing inputs to perform dose and risk assessments in a Windows environment for the purpose of demonstrating compliance with 40 CFR 61.93(a). For questions about this program, please contact:
Sanjib Chaki, P.E.
Environmental Engineer
U. S. Environmental Protection Agency
Office of Radiation and Indoor Air
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Lessard, Edward T

From: Lessard, Edward T
Sent: Monday, February 09, 2004 1:58 PM
To: Kane, Steven F; Travis, Richard J
Subject: RE: LESHC Cryo Subcommittee - AGS Snake Magnet Awareness Meeting.

Hi Steve:

Thanks. I will pass this on to Stephan Plate.

Regards.

Ed

-----Original Message-----
From: Kane, Steven F
Sent: Monday, February 09, 2004 1:36 PM
To: Travis, Richard J; Lessard, Edward T
Subject: RE: LESHC Cryo Subcommittee - AGS Snake Magnet Awareness Meeting.

Folks;
There are two issues that I gleaned from the minutes and this e-mail. The first I will deal with is the "issue" regarding installation of relief valves on bolted flanges. I reviewed the sections concerning relief valves in the B&PVC, sections UG-125-136 and Appendix M. I see no reference nor inference that the installation of relief valve on a bolted flange is not allowed. There are requirements that the loads created as a result of the discharge from a relief valve shall be considered in the design. There are also requirements that the relieving devices shall not be hindered in their operation by the discharge of the medium (liquid or gas), and that the device must be suitable for gas or liquid discharge as to its location (liquid for below liquid level).

As for the issue concerning the use of an electrically operated relief valve - I do not know if you discussed the failure modes of the electric valve. if the valve will always fail open, then I think it would be okay. If the valve fails to a purely mechanical state that will still meet the requirements of the B&PVC, that will be okay. However, the B&PVC does provide the following:

UG-126 Pressure relief valves
(a) Safety, safety relief, and relief valves shall be of the direct spring loaded type.
(b) Pilot operated pressure relief valves may be used, provided that the pilot is self-actuated and the amin valve will open automatically at nor over the set pressure and will discharge its full rated capacity if some essential part of the pilot should fail.

So an electric valve could only be considered a pilot-operated valve, and must meet the requirements of UG-126 (b).

What they may consider is using a burst disk in conjunction (not in series, but in parallel) with the electric valve, and using a lower set pressure for the electric valve. This would accommodate any operating issues they need. However, the electric valve would not be considered the pressure relief device for compliance with the B&PVC, but the burst disk would.

-----Original Message-----
From: Travis, Richard J
Sent: Wednesday, February 04, 2004 10:40 AM
To: Kane, Steven F
Cc: Travis, Richard J
Subject: FW: LESHC Cryo Subcommittee - AGS Snake Magnet Awareness Meeting.

Steve,
Some questions came up yesterday regarding the ASME Code requirements for pressure relief. The

Committee members that were present at the meeting couldn't come to a consensus.
Ed Lessard suggested that I touch base with you. Could you take a look and weigh in?
Thanks,
Rich

-----Original Message-----
From: Travis, Richard J
Sent: Wednesday, February 04, 2004 10:10 AM
To: Lessard, Edward T
Cc: Travis, Richard J
Subject: LESHC Cryo Subcommittee - AGS Snake Magnet Awareness Meeting.

Ed,
Here are the slides from yesterday's meeting. Steve Plate will issue the meeting minutes to the attendees as well as those Cryo Subcommittee members who were not able to make the meeting. He was planning to send out a request for quotation in the next couple of weeks.

Rudy, Ahmed, KC, Pete, Margareta and I attended the briefing.

We were not able to give Steve, clear direction in a couple of areas:

- The ASME Code requirements on pressure relief. The magnet division had intended to use an electrically operated relief valve in conjunction with a rupture disk. The group felt the electrically operated valve wasn't code compliant, however, we couldn't say whether a spring operated relief valve was required in addition to an appropriately sized rupture disk.
- Ahmed felt that the placement of relief devices on the upper portion of the magnet assembly (above a bolted flange) violated the code. He believed if the flange was welded, it would not be a problem. See my markup on sheet 6 of the attachment. Others in our group have encountered this arrangement before (e.g. commercial boiling water reactor pressure vessels have the SRVs attached to the vessel head which in turn is bolted to the rest of the vessel).

I told Steve that we would clarify these issues and provide clearer direction to him.

Questions:

Do we have an ASME Code SME (formal or informal) on the Committee? Steve Kane seems to be very conversant with the code requirements.

Should I go to him directly, or would you prefer to address this at the 2/12 meeting?

Rich

I am working late tonight. I hope to get the ATS SAD out for a vote, but no promises....

<< File: AGSSNAKE.pdf >>

AGS SNAKE MAGNET PARAMETERS

MAGPARAM v2.3 x15
14-Jan-04

(1)

OPERATING TEMP	4.5K
STORED ENERGY	0.4 MJ
CENTRAL FIELD, NOMINAL (max)	3T (4.2T)
OPERATING CURRENT, NOMINAL (max)	350A (515A)
CONDUCTOR, cu/sc ratio	2.5:1
WARM BORE TUBE OD / ID	6.160 / 6.000 in
WARM BORE TUBE LENGTH, FLANGE TO FLANGE	103.2 in
COLD BORE SHIELD OD / ID	6.604 / 6.504 in
COLD BORE TUBE OD / ID	7.148 / 6.948 in
YOKE DIAMETER	27.0 in
SHELL THICKNESS	0.25 in
END PLATE THICKNESS	0.50 in
C.M. LENGTH OVER END PLATES	90.50
END VOLUME PLATE THICKNESS	0.75 in
C.M. LENGTH OVER END VOLUMES	96.2 in
LENGTH OVER SHIELD	97.7 in
VACUUM VESSEL LENGTH	101.2 in
VACUUM VESSEL HEIGHT x WIDTH (center is offset from cold mass)	41.19 x 37.95 in
VACUUM VESSEL SHELL THICKNESS	1.00 in
VACUUM VESSEL END PLATE THICKNESS	0.75 in
VACUUM VESSEL LENGTH OVERALL	101.2 in
C.M. MAX ALLOWABLE WORKING PRESSURE	35.0 psia
COLD MASS He VOLUME (upper buffer 80% full)	109 L
COLD MASS WEIGHT (w/ end vols.)	15,800 lbs (estimated)
COMPLETE MAGNET ASSY WEIGHT	18,000 lbs (estimated)

OPERATION OVERVIEW:

1. Evacuate cold mass and vacuum vessel.

2. Fill shield cooling lines with LN_2 from dewar through C-AD transfer lines.

3. Pre-cool cold mass using piping on outside of shell by filling from LN_2 dewar through C-AD transfer lines.

4. Evacuate shield lines in preparation for cooling shield below 60K.

5. Activate cryocoolers.

6. Fill cold mass with LHe from dewar through C-AD transfer lines.

7. Retract LHe fill bayonet.

8. Observe instrumentation (temp sensors & level probes); energize magnet when cryogenically stable.

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9. Quench Recovery: Fill cold mass from dewar of LHe as required to supplement liquid level.

10. Maintenance Re-Cooling: follow "Operation" procedure.

PARTS & SYSTEMS TO BE ANALYZED & PRESENTED FOR LATER REVIEW

COLD MASS:

1. Containment shell – internal pressure.

2. Longitudinal shell welds.

3. End volume closure plate and welds.
   a. If pressure rating is adjusted upward, this plate must be reinforced.
   b. Cold bore tube welded to closure plates at opposite ends considered a "stay" to reduce stress and deflection.

4. Fill tubes – internal pressure.
   a. LN_2 pre-cool piping
   b. Lhe fill tube

5. Guard tube around helium fill – external pressure.

6. Buffer volumes and attachment welds – internal pressure.

7. Cold bore tube – external pressure.

8. Relief valves:
   a. Proper rating to match max operating pressure
   b. Adequate throughput to match max operating pressure
   c. Burst disc
   d. Return line sizing

CRYOSTAT:

1. Heat shield cooling lines– internal pressure.

2. Instrumentation tube (IFS) – internal pressure.

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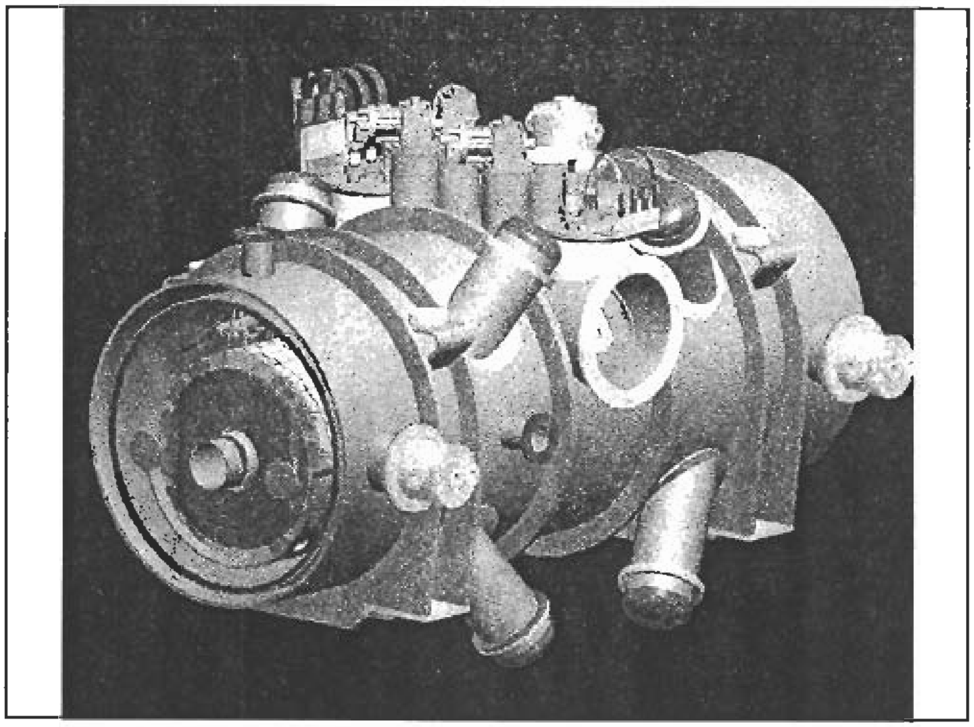

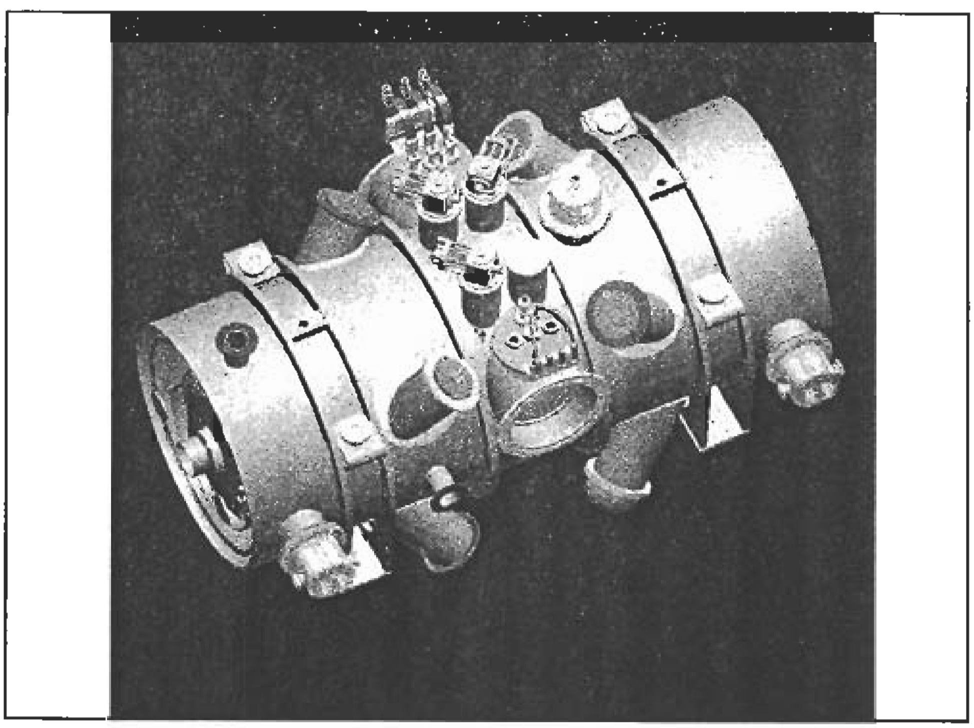

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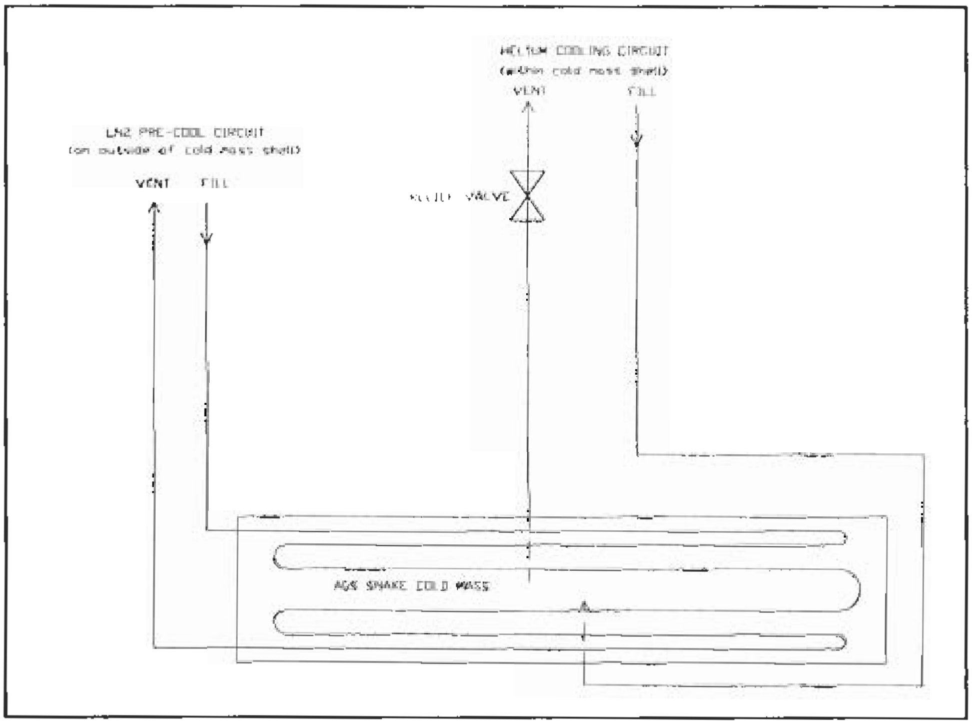
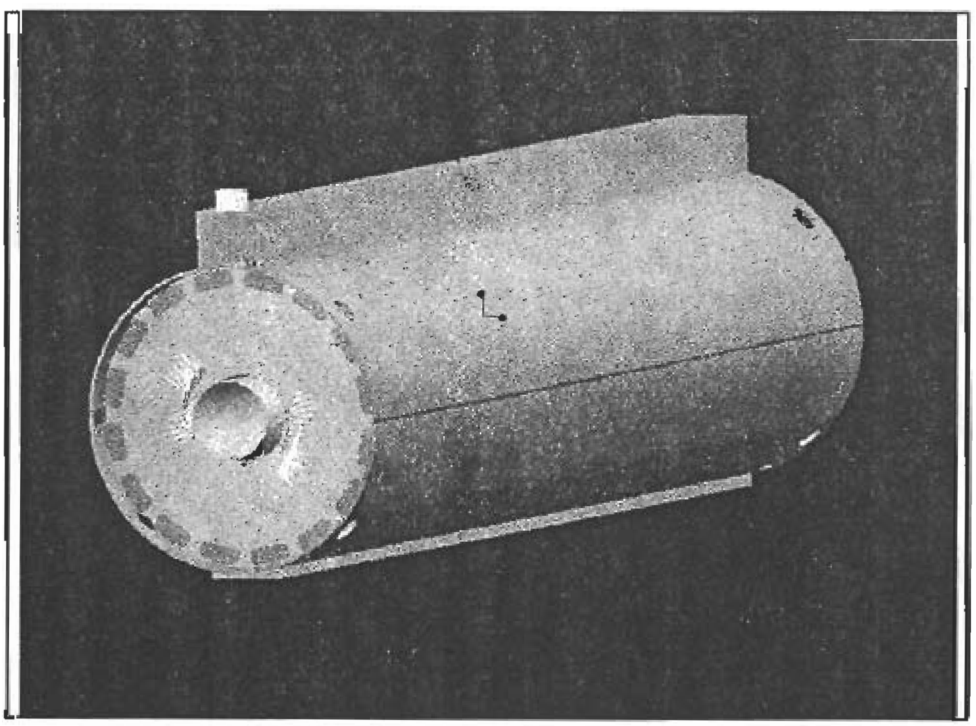
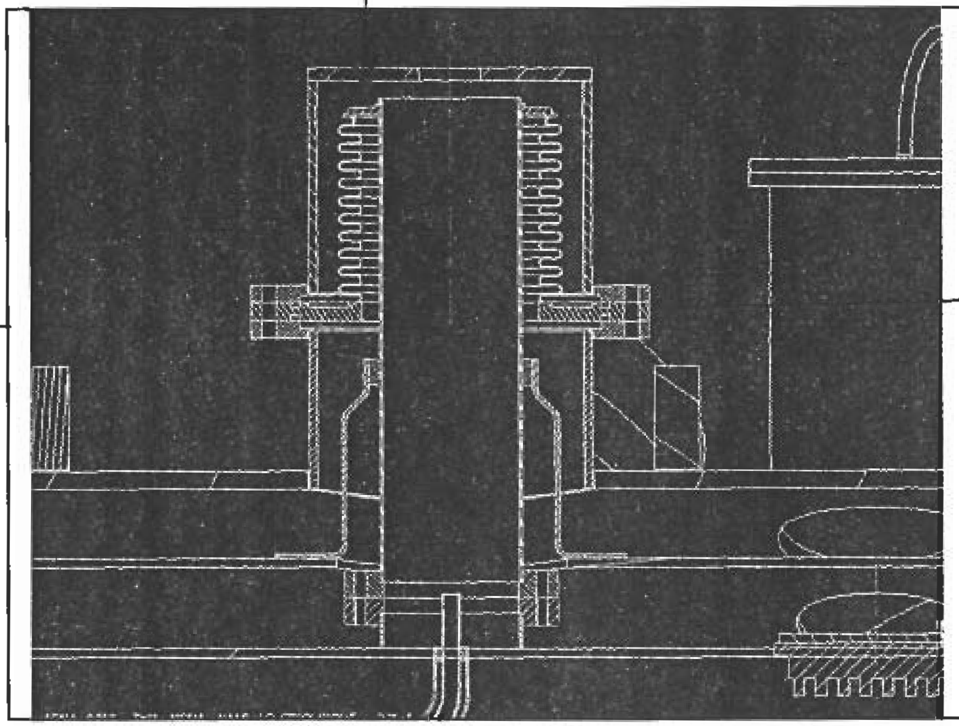


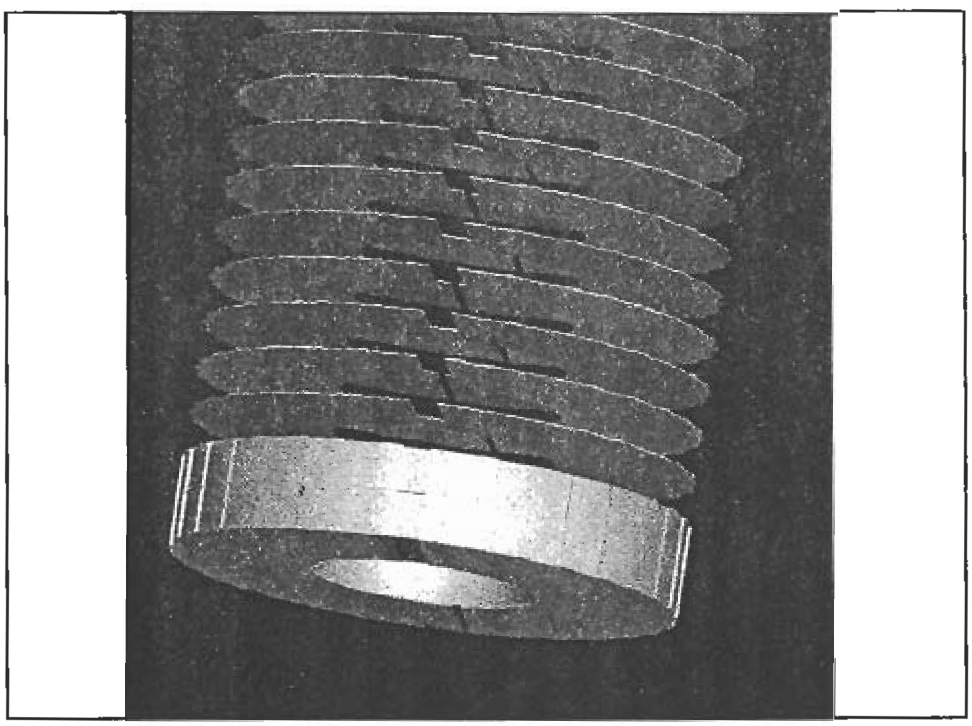
LN2 PRE-COOL CIRCUIT
(on outside of cold mass shell)
VENT
FILL
HELIUM COOLING CIRCUIT
(within cold mass shell)
VENT
FILL
VALVE
AGS SNAKE COLD MASS



PRESSURE RELIEF
FOR COLD GAS/ CRYO VOLUME



BOLTED
FLANGE



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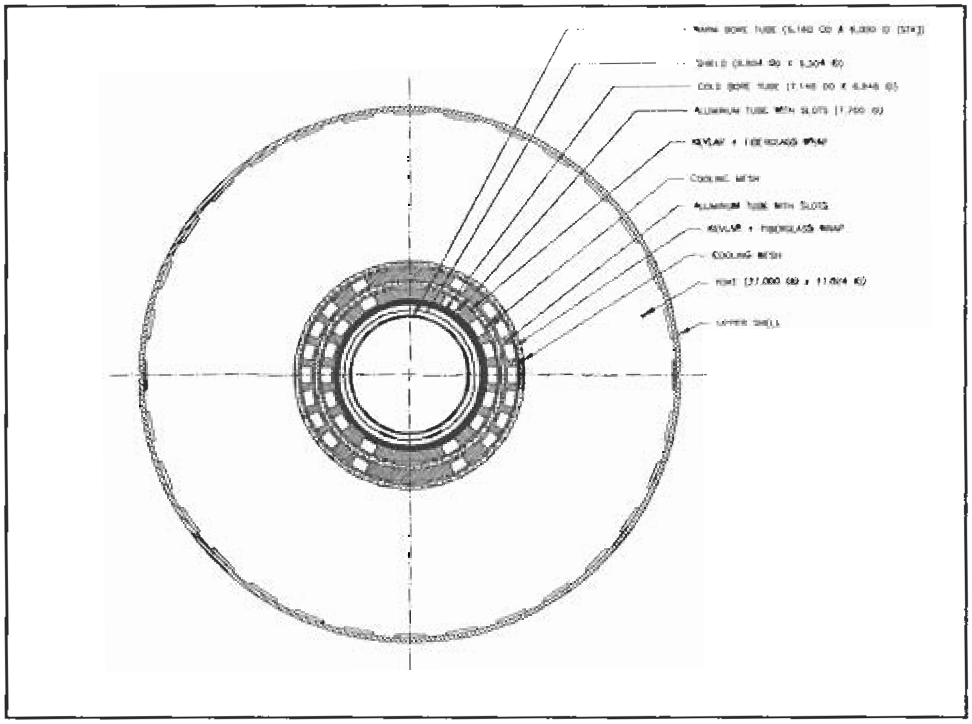
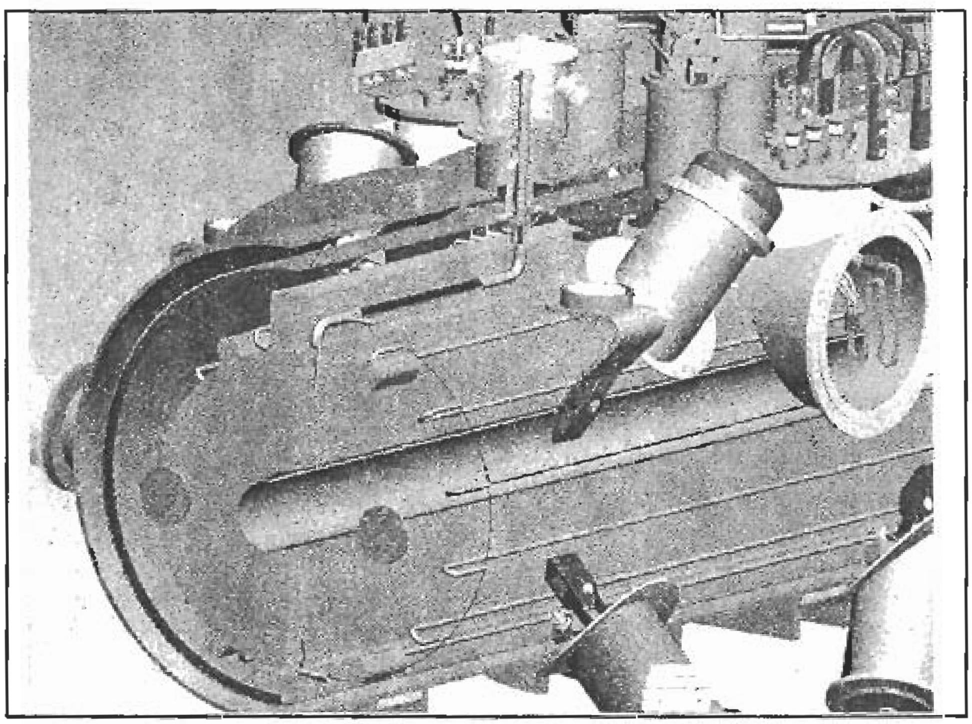

WARM BORE TUBE
SHIELD
COLD BORE TUBE
ALUMINUM TUBE WITH SLOTS
KEVLAR + FIBERGLASS WRAP
COOLING MESH
ALUMINUM TUBE WITH SLOTS
KEVLAR + FIBERGLASS WRAP
COOLING MESH
UPPER SHELL



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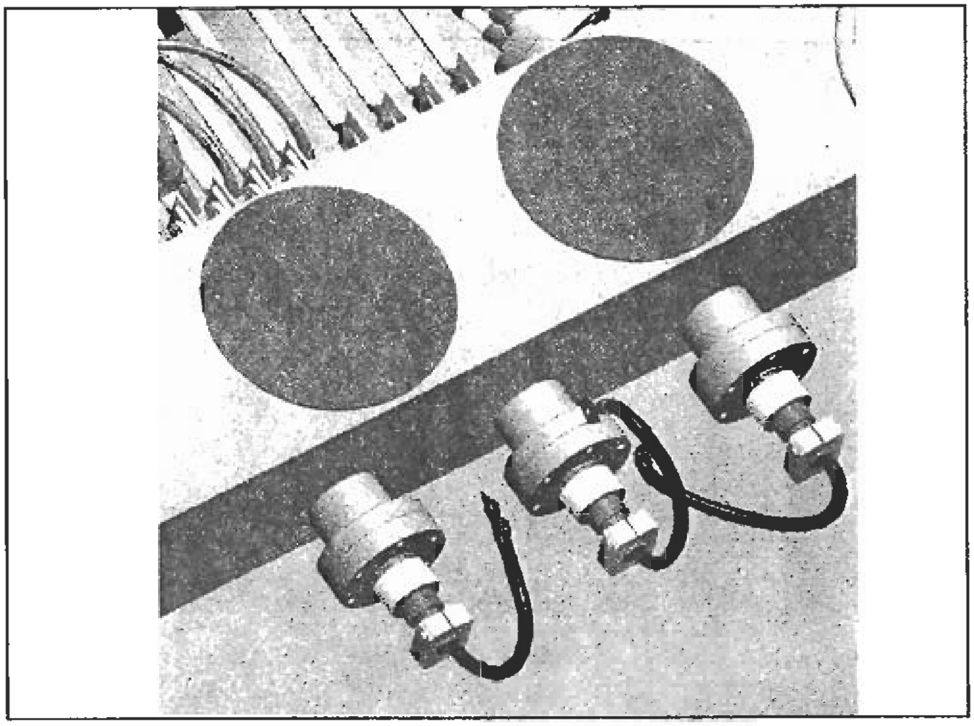

MEETING RECORD

Name of Meeting: AGS Snake Discussion

Date of Meeting: 3 February 2004 at 13:30 - Bldg. 902A Room 63

Attendees: R. Alforque, M. Anerella, A. Etkin, P. Kovach, P. Kroon, S. Plate, A. Sidi-Yekhlef, R. Travis, E. Willen, K.C. Wu

Purpose:

The meeting was held with members of the Cryogenic Safety Subcommittee, part of the Laboratory Environment, Safety, and Health Committee (CSS), in order to present known items in the AGS Snake design that would need eventual review by the CSS, and to add any issues that might otherwise be overlooked. An in-depth review of the cryogenic and pressure systems will be convened in the future in which the quantitative analysis of all identified issues will be presented.

Discussion:

In addition to the parts and systems identified for formal review in the prepared presentation that was handed out* at the meeting, the following additional issues were mentioned:

- In addition to the maximum pressure stated, the cold mass and vacuum vessel should be analyzed for full vacuum, and that pressure must stated as a parameter as well.
- To clear the LN_2 circuits of nitrogen before cooling below 77K, they should be purged using nitrogen gas first, then pumped as required.
- The heat shield lines must have a stated pressure rating and accompanying relief valve added.
- The vacuum vessel must have a relief valve (NOTE: intended but not shown).
- The cold mass relief valve size must be based on either the volume of gas generated from a quench or the volume from a catastrophic loss of vacuum, whichever causes the more severe condition.
  (ACTION: A. Sidi-Yekhlef to provide guideline of energy input to system based on vacuum loss)
- Acceptability of electrically operated solenoid valve vs. a passive spring-operated valve was questioned. Perhaps both are required.
  (ACTION: CSS to provide guidance on this topic after discussion with members)

- A relief valve mounted above a bolted connection might not meet ASME Code requirements; must be checked. A precedent that would allow bolted flanges has perhaps been set via the design of the relief valves in the RHIC valve boxes.
  (ACTION: CSS will provide its interpretation and ruling)
- The design of the cold mass pressure relief tube should be looked at further, especially regarding the temperature gradient along the tube and in the compensation bellows, and the effects of thermal convection of helium gas within the tube and outside the bellows should be studied further.
- The recondenser braze joints to the upper buffer volume will be qualified via a pressure test, not just design calculations.
- Inclusion and sizing of relief devices, flow rates, and vessel penetrations are issues the Safety typically reviews on all systems, and these will be looked at very carefully at the formal review.
- A possible ODH issue in the AGS ring will be mitigated by venting cryogens outside the tunnel, through the desirable recovery of helium and by external discharge venting of nitrogen. Nevertheless, a calculation confirming that a hazardous condition does not exist would be useful. If the design is changed, the ODH issue must be revisited.
- Safety will look in detail at the interfacing of the helium fill bayonet with the magnet fill line during the formal review. This design requires further discussion between AGS and SMD to close the gap between the desires of the two groups.
- MRI magnet design might provide some guidance on how the fill of the magnet can be accomplished during initial fill and steady state and still meet the necessary requirement of very low heat leak. The use of elastomer o-rings in areas that are exposed to cold gas should be avoided. There was discussion about the permanent attachment of the transfer line to the magnet. The tradeoff is simplicity vs. added heat leak.

*Handouts: File \\Discovery\Users\STEVEP\Brookhaven\Presentations\AGS Snake\LESHC Cryo Awareness.ppt and file \\Discovery\Users\STEVEP\Brookhaven\Presentations\AGS Snake\LESHC cryo awareness handouts.doc

Prepared by: Stephen Plate　　　Date: 5 February 2004

cc: All attendees, plus J. Glenn, M. Harrison, M. Iarocci, S. Kane, Y. Makdisi, P. Mortazavi, M. Rehak, J. Tuozzolo